

The Efficacy of Using Filtered Dichotic Words to Detect Subtle Auditory Processing Issues in  
Young Adults

A Senior Thesis

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## ABSTRACT

An auditory processing disorder (APD) is a perceptual issue affecting the way the central auditory nervous system understands and makes use of auditory information. APD is associated with young children and aging adults, and is associated with extreme difficulty understanding speech in complex listening environments. Clinical experience tells us adults between the ages of 18 and 59 years also experience listening difficulties consistent with APD, despite normal hearing test results. A popular commercial test battery of APD in adults, the SCAN-3:A, has been criticized for its lack of sensitivity for adults who experience listening difficulties consistent with APD. Dichotic listening has been shown to be sensitive to APD in both children and older adults. In an effort to increase the sensitivity of dichotic listening to the complaints of otherwise normal hearing adults, Lamoreau (2012) examined filtered dichotic word recognition in a group of adults with subjective listening complaints. Results from her study were promising, in that performance on the filtered dichotic words differentiated between control subjects and experimental subjects with borderline abnormal performance on the SCAN-3:A. The purpose of the present study was to extend the results of the Lamoreau study by recruiting additional subjects. Twenty-three right-handed young adults with normal hearing were separated into two groups (control and experimental) based on their scores from two auditory processing questionnaires. All subjects were tested with pure tone audiometry to confirm thresholds within normal limits. Four subtests of the SCAN-3:A were administered: 1) Auditory Figure Ground, 2) Filtered Words, 3) Competing Words, and 4) Competing Sentences. Following the SCAN-3:A, the dichotic word task was administered in both unfiltered and filtered conditions.

The dichotic words were filtered with a center frequency of 1500 Hz, a low-pass cutoff of 2521 Hz, and a high-pass cutoff of 892 Hz. Dichotic word recognition was also measured in three response conditions: free recall, directed right, and directed left. The unfiltered condition preceded the filtered condition, and the free recall response condition preceded the directed recall conditions. Results showed poorer performance in speech recognition for filtered dichotic words relative to the unfiltered dichotic words. Overall, there was not a significant difference in performance between groups, but there were intriguing findings for four individuals from the experimental group. These four subjects with subjective listening complaints performed normally on the SCAN-3:A, but had abnormal results for the filtered dichotic words. The abnormal performance on the filtered dichotic words leads us to believe the task may be sensitive to subjective listening complaints of young adults with normal hearing. In the future, changes will be made to the inclusion criteria to reduce variability in subjects and to the procedure to lighten the cognitive load of the directed recall condition (repeat directed ear only) in order to show a more accurate representation of performance and ear advantage.

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## CHAPTER 1

### INTRODUCTION AND LITERATURE REVIEW

Young adults that experience difficulty understanding or listening in complex acoustic environments have gone to audiologists in search of answers for their “hearing difficulties”. In many cases, however, a hearing evaluation shows normal hearing sensitivity. In some cases, these individuals will receive additional testing to determine if they have an auditory processing disorder. Auditory processing disorders are typically assessed with a test battery that includes multiple tests of central auditory function. The most common test used to screen for auditory processing disorders is the SCAN 3:A (Keith, 2009). “Hearing difficulties”, or subjective listening complaints in young adults do not seem to be explained by the SCAN 3:A results, as they often perform normally on this test. Therefore the SCAN-3:A is unable to consistently diagnose auditory processing issues and is likely insensitive to the listening complaints of some young adults (Lovett & Johnson, 2010). Dichotic listening is a commonly measure used in the assessment of auditory processing disorders. The dichotic speech recognition task involves the listener hearing two different stimuli presented to the ears simultaneously. The listener is required to repeat the stimuli from both ears (i.e., free recall) or the stimuli from a cued-ear (directed recall) (Keith & Anderson, 2007). Dichotic listening can be used to differentiate normal and abnormal auditory processing (Keith & Anderson, 2007). The current study proposed that using filtered words in a dichotic speech recognition task would be more sensitive to auditory processing complaints in young adults than the SCAN 3:A.

## **Auditory Processing Disorder**

Auditory Processing Disorder (APD) is defined as a perceptual issue affecting the way in which the central auditory nervous system (CANS) understands and makes use of auditory information [American Speech, Language and Hearing Association (ASHA), 2005; American Academy of Audiology (AAA), 2010]. APD is typically associated with normal hearing. People with APD have difficulties listening in background noise, complex listening environments, distinguishing between similar sounds, following multi-task directions, and localizing sounds. Typically, APD is found in children and older adults. In the UK, APD has been reported in young adults that have had a traumatic brain injury (Saunders & Haggard, 1989), but in the United States, the prevalence of APD in young adults without hearing loss or a brain injury has not been studied. As APD can be secondary to brain injury, it can also co-exist with language and behavioral disorders. Children born prematurely may have auditory processing issues, but they are expected to improve with age (Davis et al, 2001). Attention Deficit/Hyperactive Disorder (ADHD) may be related to APD (Gascon, Johnson, & Burd, 1986; Pillsbury et al., 1995), however, they are two different disorders. Therefore, it is important that the assessment and diagnosis of APD considers the patient as a whole from a multidisciplinary perspective that is specific to auditory issues and with the consideration of potential attentional issues (AAA, 2010).

Young adults with normal peripheral hearing are rarely considered to have auditory, or listening issues. Anecdotal clinical reports suggest, however, that some young adults experience what they consider to be 'hearing problems'. These young adults with listening complaints have difficulty hearing in background noise and remembering auditory stimuli they have heard.

This population has normal peripheral hearing and typically performs in the normal to borderline range on the current clinical test battery for APD, the SCAN-3:A (Keith, 2009). This population is of interest to us because their complaints do not seem to be explained by the SCAN-3:A.

### **SCAN-3:A**

The SCAN-3:A (Keith, 2009) is a current clinical test battery that screens for auditory processing disorders in children and adults. The SCAN is used widely among audiologists who screen for APD (Emanuel, Ficca, & Korczak, 2011). It has many forms, derived from the SCAN-A Screening Test for Auditory Processing Disorders for children (Keith, 1986), including the SCAN-3:A normed specifically for adults. It is comprised of multiple subtest with the goal of assessing a patient's listening abilities across various auditory domains. The SCAN-3:A includes tests of 1) Filtered Words, 2) Auditory Figure Ground, 3) Competing Words, 4) Competing Sentences, and 5) Gap Detection (Keith, 2009). A composite score is derived based on all subtest and patients are categorized as normal, borderline, or disordered based on their overall performance. Some research findings have shown the SCAN-3:A to be insensitive to the complaints of young adults with auditory processing issues (Lovett & Johnson, 2010). Recently, Lamoreau (2012) used a filtered dichotic word task to evaluate auditory processing issues in young adults with listening complaints, yet normal performance on the SCAN-3:A. The results from Lamoreau were inconclusive, yet suggested that the filtered dichotic word recognition task may be more sensitive to auditory processing deficits in this population.



## **Dichotic Speech Recognition and the Right Ear Advantage**

Dichotic speech recognition is the presentation of different stimuli to both ears simultaneously, asking the subject to repeat both of the stimuli they heard (Keith & Anderson, 2007). Dichotic speech recognition was first discussed in relation to the listening difficulties faced by air traffic control personnel (Broadbent, 1954). Air traffic control personnel had difficulties when signals from more than one airplane were being received at once. Broadbent (1964) played messages in both ears simultaneously, and the speed of the presentation affected how the subjects responded. If the messages were presented rapidly, they would repeat the message from one ear followed by the other ear. The research done following Broadbent (1954) looked at the performance on dichotic tasks of normal-hearing listeners compared to that of listeners with brain lesions (Kimura, 1961a, b). Kimura (1961a, b) was the first to report a right ear advantage (REA). Kimura (1961a) found that the left hemisphere is responsible for processing verbal information which explains the REA because of the contralateral auditory pathways. A REA is typically found in young adults with normal hearing (Dirks, 1964; Kimura, 1967; Wilson & Jaffe, 1996; Wilson & Leigh, 1996; Strouse & Wilson, 1999; Roup 2011). The REA is a representation of the asymmetry of the cerebral hemispheres in the perception of speech, and the strength of the contralateral auditory pathways (Kimura, 1961a, b; Kimura, 1967). This is known as the structural theory of dichotic listening. First, the left cerebral hemisphere is known to be dominant in the perception of verbal (speech) stimuli (ref). And second, during dichotic speech recognition, stimuli are processed via contralateral auditory pathways (Kimura, 1961a, b). This results in speech stimuli presented to the right ear having

preferential access to the speech processing centers of the left cerebral hemisphere. In contrast, stimuli presented to the left ear is first sent contralaterally to the right cerebral hemisphere and must cross the corpus callosum to be perceived in the left cerebral hemisphere. The structural theory explains the REA, in which the stimuli presented to the right ear is processed more efficiently (Kimura, 1961a; Kimura, 1961b; Kimura, 1967; Bryden, 1988). The magnitude of the REA in dichotic listening tasks is variable dependent on the type of stimuli being used (Bryden, 1988).

Words heard in the right ear have the most direct pathway to the left hemisphere, where the brain processes speech information. Speech information coming to the right ear is processed much more efficiently because of the contralateral pathway of the auditory system (Dirks, 1964; Kimura, 1967). As a result, normal-hearing young adults typically perform better in the right ear than the left ear, reflective of the dominance for language attributed to the left hemisphere (Keith & Anderson, 2007). This difference between ears is known as the REA (Kimura, 1967). Free recall and directed right conditions typically result in a REA whereas the directed left condition results in a left ear advantage (LEA). Normal hearing adults tend to have a small REA on dichotic listening tasks. Roup (2011) found that with normal hearing adults, when the task was made more difficult, the performance went down, but the REA did not change. This finding, along with the idea that populations with age-related decline or auditory processing issues tend to have larger ear advantages (Roup, Wiley, & Wilson 2006) tells us that a dichotic listening task can differentiate adults with auditory processing issues. When the task becomes more difficult, if the ear advantage gets larger, it should signify an auditory processing

issue. In this study, during the dichotic word task, we looked at the ear advantages of the subjects with subjective listening complaints compared to the group with no listening complaints to determine if there was a significant difference.

### **Handedness**

Handedness creates variability in results in dichotic listening and how the brain processes information. The ear opposite the dominant hand is more efficient in speech processing. For people that process information in the left hemisphere, or are right handed, a REA is present (Kimura, 1961b). Speech processing is not necessarily consistent with hand dominance, but it has been found that left handedness creates more variability in results. For right-handed subject, speech recognition performance is better for stimuli presented to the right ear than the stimuli presented to the left ear (Wilson & Jaffe, 1996). To reduce this variability, this study uses only right handed subjects.

### **Response Conditions**

Dichotic listening can be measured in two different response conditions: free recall and directed recall. Free recall is when the subject receives different stimuli in both ears simultaneously and is directed to repeat back both words they heard but in any order. For example, if the subject heard “ball” in the right ear and “cat” in the left ear, they may repeat back “ball, cat” or “cat, ball”.

Directed Recall is when the subject is instructed to repeat the stimuli heard in the directed ear first. In some studies, the subject must only repeat the word presented to the ear they are directed to, but in this study the subjects recited the word presented to the directed

ear followed by the stimuli heard in the opposite ear. During the dichotic word task we will be giving the subject three different conditions, two of which are directed to either the left or right ear. This allows the subject to have a listening strategy and improve performance for the directed ear. The performance will in theory improve because of the lightened cognitive load when directed to an ear to repeat back first. The directed conditions will enable us to analyze the effect on the ear advantages. Typically, people with age-related hearing loss or auditory processing issues will have larger ear advantages (Roup, Wiley, & Wilson 2006). By directing the subject to each ear, it will allow us to compare the ear advantages of the subjects with complaints to the subjects without complaints.

### **Filtered Speech Recognition**

Filtering of the speech signal is one way to increase the difficulty of the perceptual task. Low-pass filtered words have been used to evaluate the speech recognition abilities of people with temporal lobe lesions (Bocca, Calearo, Cassinari, 1954). The authors found that performance for the ear opposite the lesion was much worse than the ear ipsilateral to the lesion during a low-pass filtered speech recognition task. This difference in performance between ears was not present during pure-tone audiometry or unfiltered speech recognition tasks, demonstrating that filtered speech has the ability to decrease the redundancy of the speech signal and increase the sensitivity to the brain lesion. With a breakdown of redundancy of the CANS (i.e. lesion), the listener's performance will be significantly worse on a filtered speech recognition task than on an unfiltered speech recognition task because the CANS would be incapable of compensating for the missing information. Someone with a normal functioning

CANS should not have significantly different results across unfiltered and filtered conditions (Krishnamurti, 2007). The filtered speech recognition task is able to separate patients with an abnormal CANS from normal functioning CANS.

Filtered dichotic stimuli has the ability to increase the REA and show the asymmetry of the CANS compared to unfiltered dichotic word tasks (Dirks, 1964; Martin, Gibson, & Huston, 2012). Martin, Gibson, and Huston (2012) found that REAs significantly increased from free recall to directed recall and performance was better in the right ear than the left ear. Dirks (1964) studied the presentation of dichotic stimuli presented a multitude of ways. His conclusions were that there is a significant REA when the stimuli presented to both ears was repeated back and that when only the stimulus to the directed ear needed to be recited, there was still a small REA. Lamoreau (2012) proposed that using a filtered dichotic word task would be sensitive to subjective listening complaints in young adults with normal hearing. She found that there was no significant difference between the control and experimental groups, but when separated by performance on the SCAN-3:A (normal and borderline performance), there was a significant difference, showing subjects with borderline scores on the SCAN-3:A had much worse performance on the filtered dichotic word task. Lamoreau (2012) also found that ear advantages were larger in the filtered condition and that right ear performance was significantly better than left ear performance for all subjects.

### **Goals of the Present Study**

The goal of the present study was to determine if a filtered dichotic word task was sensitive to the subjective listening complaints in young adults with normal hearing. It was

hypothesized that: 1) filtering would result in a significant decrease in dichotic recognition performance relative to unfiltered words for both an experimental group (subjects with listening complaints) and a control group (no listening complaints); and 2) the REA in the dichotic filtered condition would be significantly larger for the experimental group relative to the control group.

## METHODS

### Subjects

Twenty-three young adults 18-39 years (mean age = 22.3 years) with normal hearing participated in the present study. Subjects were divided into two groups based on presence or absence of subjective listening complaints. Eleven subjects had no listening complaints and served as the Control group. Twelve subjects had subjective listening complaints and served as the Experimental group. Subjects were considered to have subjective listening complaints if they had: 1) an answer of “almost always”, “always”, or a score of 11 or more on a screening questionnaire (Lamoreau, 2012; see Appendix A); or 2) a score of -20 or less on a revised version of the Children’s Auditory Processing Performance Scale (R-CHAPPS; Smoski, 1990; Lamoreau, 2012). The screening questionnaire consisted of five questions containing behaviors linked with APD (AAA, 2010). The R-CHAPPS consists of 36 items that assess how well an individual perceives their listening ability in a variety of listening environments (noise, quiet, ideal, multiple inputs, auditory memory, and auditory attention span). Pure tone thresholds were measured by both air conduction and bone conduction to insure normal hearing (20 dB HL or better 250-8000 Hz). Inclusion requirements for the study were as follows: 1) native English speaker; 2) no history of or current ear pathologies; 3) no developmental or language disorder; 4) normal otoscopy; 5) dominantly right-handed based on the Edinburgh Handedness Inventory (Oldfield, 1971); and 6) normal tympanometry and acoustic reflexes. Before case history was collected and tests were conducted, the subject gave consent. Subjects were recruited from

The Ohio State University student population, as well as the surrounding area, all in Columbus, OH. All subjects were compensated for their time.

## **Materials**

Auditory processing abilities were measured in all subjects using the SCAN-3:A test battery (Keith, 2009). The SCAN-3:A includes the following subtests: Filtered Words, Auditory Figure Ground, Competing Words, Gap Detection and Competing Sentences. Performance is considered for individual subtests, across subtests and as a function of age. Performance on the SCAN-3:A can be classified as normal, borderline or disordered.

Dichotic listening was measured using the monosyllabic words from Findlen and Roup (2011), and adapted from Boothroyd and Nitttrouer (1988). A total of 100 words were recorded by a male speaker, which provided consistency with the SCAN-3:A test battery. The words were paired according to the Neighborhood Activation Model of speech perception (Luce & Pisoni, 1998), ensuring both words in the pair had similar recognition difficulty (e.g., word frequency and density). The 100 words were paired three times to create three separate dichotic word-pair lists. In order to create the filtered dichotic words, the stimuli were filtered using a digital eighth-order Butterworth filter (48 dB/octave). The center frequency was 1500 Hz, the high-pass cut was of 892 Hz, and the low-pass cut off was 2521 Hz. The original and filtered dichotic word stimuli were recorded on a compact disc with a 5 second interval between word pairs.

## **Procedures**

The SCAN-3:A was administered first to all subjects and used to provide an information on auditory processing abilities from a test battery perspective. Four of the SCAN-3:A subtests



were used, including: Auditory Figure Ground, Filtered Words, Competing Words, and Competing Sentences. After the SCAN-3:A was completed, a break was offered to each subject. Following the SCAN-3:A, the dichotic word task was administered. Each subject received three lists each of filtered and unfiltered dichotic words. Dichotic word recognition was measured in three response conditions: free recall, directed right, and directed left. In the free recall condition, subjects were instructed to repeat both words in any order. In the directed recall conditions, the subjects were instructed to repeat the word from the directed ear first, followed by the word from the opposite ear. For example, in the directed right condition, subjects repeated the word presented to the right ear first followed the word presented to the left ear. The unfiltered dichotic word task preceded the filtered dichotic word task. The free recall response condition was administered first for both filtered conditions. Practice lists were used prior to each response condition to insure that the subject understood the task. The lists were randomized for each subject, but the free recall condition was always given first.

All speech stimuli were routed from a compact disc player through a two-channel audiometer (Grason Stadler 61) to insert earphones (EAR 3A). Stimuli were presented at 50 dB HL. All equipment used in the study (tympanometer and audiometer) was calibrated according to the appropriate American National Standards Institute (ANSI) standards (ANSI, 1987, 2004).

## CHAPTER 3

### RESULTS

#### **Group Results**

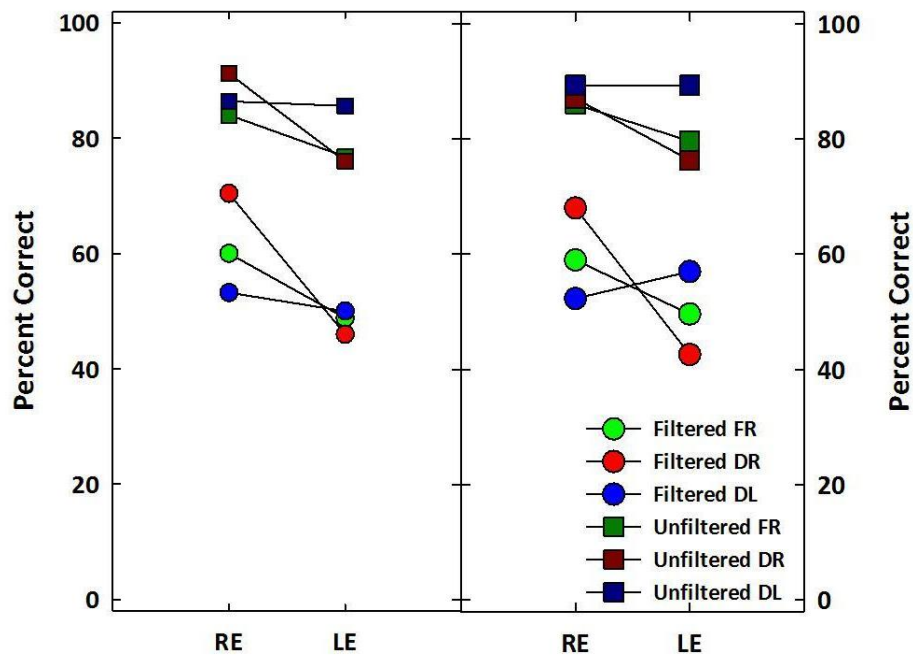
##### *Dichotic Word Recognition*

Figure 1 presents mean dichotic word recognition as a line graph for both unfiltered and filtered conditions across all response conditions. Although the data are not continuous, the lines are included for illustration purposes. Table 1 presents means and standard deviations for dichotic word recognition performance as a function of group (control and experimental), filtering condition (unfiltered and filtered) and response conditions (free recall, directed right and left). As seen in both Figure 1 and Table 1, dichotic word recognition performance differed as a function of filtering. Overall performance was best for the unfiltered response conditions and poorest for the filtered response conditions. Performance also varied as a function of response condition and ear, with best performance on words presented to the right ear for free recall and directed right and left. For the experimental group, performance was best on words presented to the left ear in the directed left condition when the stimuli were filtered. On average, overall dichotic word recognition performance was similar between the two groups across filtering and response conditions.

Prior to statistical analysis, the data were transformed to rationalized arcsine units in order to address the error in variance associated with percentage data (Studebaker, 1985). The transformed data were subjected to a repeated measures analysis of variance (ANOVA) with

**Table 1.** Means (and standard deviations) for dichotic word recognition performance (in percent correct) for unfiltered and filtered words across response conditions for control and experimental groups.

		Right Ear (%)	Left Ear (%)	RE-LE (%)
<i>Free Recall</i>				
Control Group	Unfiltered	84.0 (7.3)	76.8 (10.6)	7.2 (8.8)
	Filtered	60.0 (15.5)	48.8 (15.9)	11.2 (19.4)
Experimental Group	Unfiltered	86.0 (10.1)	79.6 (10.1)	6.3 (9.5)
	Filtered	59.0 (11.7)	49.6 (10.3)	9.3 (15.9)
<i>Directed Recall Right</i>				
Control Group	Unfiltered	91.2 (7.2)	76.0 (13.5)	13.6 (12.3)
	Filtered	70.4 (15.9)	46.0 (18.1)	24.4 (13.2)
Experimental Group	Unfiltered	87.0 (7.4)	76.3 (9.4)	10.6 (12.9)
	Filtered	68.0 (14.2)	42.6 (12.7)	25.3 (19.1)
<i>Directed Recall Left</i>				
Control Group	Unfiltered	86.4 (10.1)	85.6 (6.5)	0.8 (7.9)
	Filtered	53.2 (19.8)	50.0 (10.5)	3.2 (21.5)
Experimental Group	Unfiltered	89.3 (8.5)	89.3 (5.4)	0.6 (8.9)
	Filtered	52.3 (12.7)	57.0 (15.5)	-8.5 (16.8)



**Figure 1.** Mean dichotic word recognition performance (in % correct) for the right ear (RE) and left ear (LE) as a function of subject group: control (left panel) and experimental (right panel). Data are presented for unfiltered and filtered words for all response conditions: free recall (green), directed right (red) and directed left (blue). Although data are not continuous, the RE and LE data points are connected by lines for illustration purposes.

*group* as the between-subjects variable and *filtering*, *response condition* and *ear* as within subjects variables. Results for the between-subjects factor of *group* did not reveal a significant difference in performance [ $F_{(1, 21)} = 1364$ ;  $p > 0.05$ ]. Results revealed a significant main effect of *filtering* [ $F_{(1, 21)} = 1109$ ;  $p < 0.05$ ]. For both subject groups, dichotic word recognition performance was significantly poorer across response conditions due to filtering (see Table 1). A significant main effect was also found for *response condition* [ $F_{(2, 40)} = 4$ ;  $p < 0.05$ ]. Post hoc t-tests with Bonferroni correction revealed significantly ( $p < 0.016$ ) better performance in the unfiltered condition for directed left relative to both free recall and directed right. Finally, a significant main effect was found for *ear* [ $F_{(1, 21)} = 42$ ;  $p < 0.05$ ]. Specifically, dichotic word recognition performance was significantly better for the right ear than for the left ear.

Significant interactions were found for *response condition*  $\times$  *group*, *filtering*  $\times$  *response condition*, and *response condition*  $\times$  *ear*. *Response condition*  $\times$  *group*, *filtering*  $\times$  *response condition*, and *response condition*  $\times$  *ear* can all be explained by the experimental group's performance for the filtered dichotic word task for the directed left condition. These interactions can be explained by better performance of the left ear compared to the right ear. This LEA and cross pattern in the line graph show a significant interaction.

Differences in ear advantage were examined using a repeated measures ANOVA with *group* as the between-subjects factor, and *filtering* and *response condition* as the within-subjects factors. No significant differences in ear advantage were found for group. Results revealed a significant main effect for response condition [ $F_{(1.8, 38)} = 22$ ;  $p < 0.05$ ] and filtering response condition [ $F_{(1.8, 38)} = 3$ ;  $p < 0.05$ ]. These interactions can be explained by the

experimental group's better overall performance for the left ear in the filtered directed left condition.

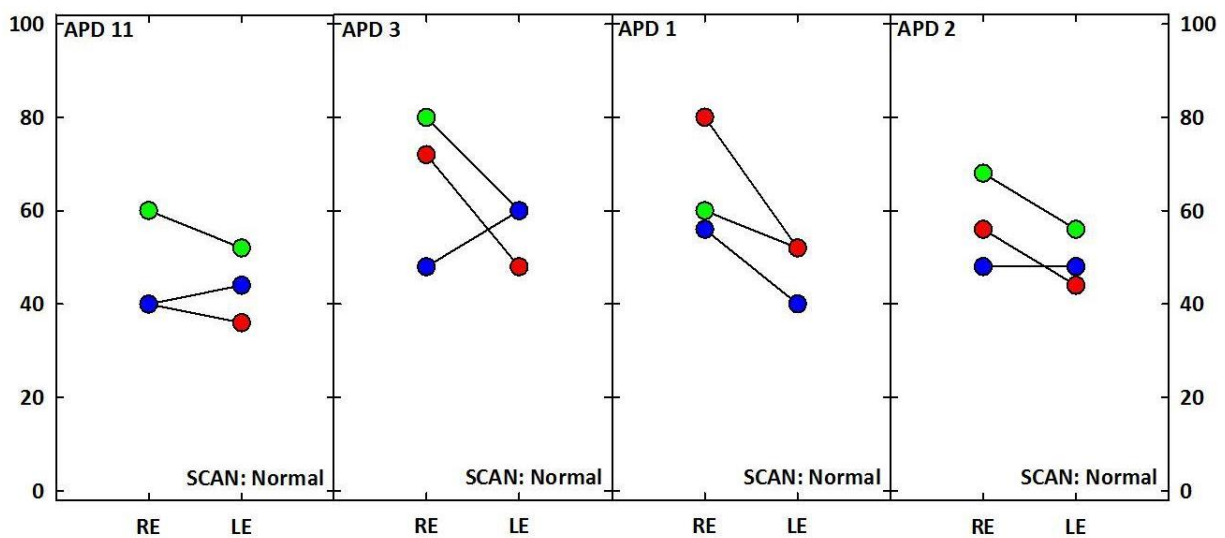
### *Ear Advantage*

The data was subjected to ANOVA. No significant difference was found between groups, but a significant main effect was found for *filtering*. There was a significant difference in ear advantage between unfiltered vs. filtered (free recall, directed right, directed left). Post hoc t-tests with Bonferroni correction showed that the ear advantage was significantly larger for the filtered words in the directed right condition only. This significant larger REA was found in both the control group and the experimental group.

### **Individual Results**

The average data did not show a significant difference between the two groups, however, four individuals from the experimental group were found to exhibit atypical results. Figure 2 includes individual dichotic word recognition performance for the filtered condition for the four individuals with atypical results. Atypical results are defined as performance deviating from the expected results for individuals with normal hearing and with no auditory processing issues. For a normal hearing individual with no auditory processing issues, a REA is expected for the free recall and directed right conditions and a LEA is expected for the directed left condition. Performance is expected to be poorest in the free recall condition due to the greater cognitive load. These expected results were not found for these four subjects in the experimental group. Specifically, all four subjects failed to demonstrate an improvement in recognition performance in the directed recall conditions relative to the free recall condition.

The four subjects with atypical performance on the filtered dichotic word task scored normal on the SCAN-3:A. Subject E11 performed best in the free recall condition, had a small REA for the directed right condition, and a small LEA for the directed left condition. Subject E3 also performed best in the free recall condition, but had a much greater REA and LEA in the directed conditions. Subject E1 had REAs in all 3 conditions, with the biggest REA in the directed right condition. The free recall performance was better than the directed left performance, but worse than the directed right performance. Finally, Subject E2 performed best in the free recall condition, had a small REA in the directed right condition, and had no ear advantage in the directed left condition. None of these four subjects performed poorest in the free recall condition, suggesting atypical dichotic recognition results.



**Figure 2.** Individual data are presented for four subjects from the APD group with normal SCAN 3:A scores, yet atypical patterns of performance on the filtered dichotic word task. Data is presented for free recall (green symbols), directed right (red symbols) and directed left (blue symbols) for right and left ears.



## CHAPTER 4

### DISCUSSION

The present study sought to determine if a filtered dichotic word task is sensitive to the subjective listening complaints of young adults with normal hearing. It was hypothesized that there would be a significant difference in performance on the filtered dichotic word task between the subjects with subjective listening complaints with normal to borderline SCAN:3-A scores (experimental group) and a group of normal controls. This hypothesis, however, was not supported by the data. The filtered dichotic word task did not differentiate the experimental group from the control group in overall recognition performance or in the magnitude of the ear advantage. Therefore, at the group level, the filtered dichotic word task was not sensitive to the subjective listening complaints of these subjects based on a screening questionnaire and an auditory processing questionnaire.

Filtering of the dichotic stimuli did, however, result in significantly poorer recognition performance relative to the unfiltered stimuli for both subject groups. During the unfiltered dichotic word task, both the experimental and control groups performed as expected, with free recall resulting in the lowest performance and ear advantages consistent with the literature (Martin et al., 2012; Roup et al., 2006; Roup, 2011). Recognition performance changed as a function of the filtered dichotic word task. Filtering the words made the task more difficult, lowering performance, increasing the size of the ear advantage, and making results more variable. The results of the present study were consistent with Martin et al. (2012), who reported increases in the dichotic ear advantage due to filtering of the dichotic stimuli.

## **Individual Results**

For a normal hearing individual with no auditory processing issues, a REA is expected for the free recall and directed right conditions and a LEA is expected for the directed left condition. Performance should be poorest in the free recall condition relative to the directed recall conditions due to the greater cognitive load. Inspection of the individual data revealed four individuals from the experimental group that failed to demonstrate this expected pattern. Specifically, all four subjects failed to demonstrate an improvement in recognition performance in the directed recall conditions relative to the free recall condition. In other words, they were unable to take advantage of the reduced cognitive load in the directed recall conditions to improve their dichotic performance. For these four subjects, the filtered dichotic word task did not differentiate them from the rest of the subject pool.

The four subjects with atypical performance on the filtered dichotic word task scored normal on the SCAN-3:A. With normal results on the SCAN-3:A and atypical performance on the filtered dichotic word task, it leads us to believe that the filtered word task was sensitive to their subjective listening complaints. The results for these subjects are consistent with an auditory-based deficit for dichotic listening and suggest that the filtered dichotic word task may be sensitive to subjective listening complaints of adults with normal peripheral hearing (Jerger & Martin, 2006).

## **Conclusions and Future Research**

The lack of evidence that the filtered dichotic word task is sensitive to the subjective listening complaints of young adults mean: 1) that the task is not as sensitive as hypothesized,

or 2) a test battery approach that includes a greater number of auditory processing tasks would be more sensitive to subjective deficits. Clearly, the one behavioral task used in the present study was not enough to show deficits for the whole group. The present study included only one test, a filtered dichotic word task. Significant differences between groups may have been found if a test battery approach was used.

It has been suggested that individuals with subjective listening complaints may have deficits in their ability to attend to relevant stimuli. The inclusion of a test of attention, such as the Flanker task, would demonstrate if an attention deficit was present in these individuals. After consideration of the results from the Flanker task, we would be able to speculate if the subject has an attention disorder with symptoms that appear in the form of auditory issues or if the listening abilities are stemming directly from an auditory issue.

Physiologic measures can provide another means of assessing the auditory system in listeners with subjective complaints. Specifically, contralateral suppression of otoacoustic emissions (OAEs) provides insight to the function of the efferent auditory system. Suppression of OAEs with the presentation of contralateral noise is present in normal auditory systems and represents an inhibitory response of the efferent auditory system. A lack of contralateral suppression in listeners with subjective APD complaints would provide physiologic evidence of a lack of inhibition, or a deficit in the ability to ignore competing/extraneous auditory stimuli.

The criteria to qualify for the experimental group caused variability in the results. Because of the “and/or” stipulation of the two questionnaires, the subjects that qualified for the experimental group had a very broad range of subjective listening complaints. Making the

inclusion criteria tighter would allow for more consistency in the listening complaints and ideally widen the gap between performance of the control and experimental. Also, a few changes to the dichotic procedures would theoretically further separate the performance from the control and experimental groups. In the present study, the subjects were asked to repeat the stimuli presented to both ears during the dichotic listening task. During the directed recall conditions, the cognitive load was lightened by directing the subject to a specific ear, but they were still required to repeat the stimuli heard in both ears. By only requiring the subject to repeat the stimuli heard in the directed ear, it would further lighten the cognitive load, potentially showing a more accurate representation of ear advantages.

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## Appendix A

### Auditory Processing Screening Questionnaire

Responses:   Never  
                  Seldom  
                  Occasionally  
                  Half the time  
                  Generally  
                  Almost Always  
                  Always

- 1) Do you have problems telling where a sound is coming from?
- 2) Do you have a hard time hearing a specific person speaking to you in the presence of background noise?
- 3) Do you have difficulty ignoring environmental sounds (i.e., newspaper rustling, refrigerator running) and focusing on the primary message (i.e. someone speaking to you)?
- 4) Do you feel you need spoken information repeated in order to understand the message?
- 5) Do you have difficulty following spoken instructions?